Professional paper

IMPLEMENTATION OF GREEN COMPUTING IN INCREASING ICT SECURITY

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Abstract: *Green computing encompasses practices and technologies aimed at reducing the negative impact of ICT on the natural environment. The goal is to optimize energy performance, reduce carbon emissions, increase resource efficiency, and promote responsible disposal of electronic waste. All of this includes a wide range of activities, from the design of energy-efficient hardware components and the development of software that minimizes energy consumption, to the implementation of sustainable data center management strategies and the recycling of electronic devices. This paper describes the basics of green computing and the importance of its application for increasing ICT security.*

Keywords: *green computing, IT, security, certifications*

1. INTRODUCTION

Green computing (Green IT, Sustainable IT, Digital Sustainability) encompasses practices and technologies aimed at reducing the negative impact of ICT on the natural environment. The goal is to optimize energy performance, reduce carbon emissions, increase resource efficiency, and promote responsible disposal of electronic waste. This includes a wide range of activities, from the design of energy - efficient hardware components and the development of software that minimizes energy consumption, to the implementation of sustainable data center management strategies and the recycling of electronic devices. (Hruška, 2024).

A major problem is the presence of hazardous compounds and heavy metals in electronic waste. According to the US Environmental Protection Agency, Americans annually throw away more than two million tons of electronic waste, making electronic waste one of the fastest growing parts of municipal waste. When these electronics break down, heavy metals and other harmful substances are released. Therefore, electronic waste must be collected and recycled separately from other waste, and recycling electronic waste is expensive. Green computing greatly reduces the amount of electronic waste that decomposes uncontrollably and pollutes the environment. Reusing reduces costs, but that is not the only benefit. As a side effect of reuse, packaging, water and energy consumption are also reduced (Smith, 2014).

Energy consumption is the foundation of an environmentally sustainable IT system. Higher consumption not only increases costs, but also contributes to higher greenhouse gas emissions. Energy consumption is a major cost in the operations of any company. Optimizing electricity consumption reduces costs while at the same time contributing to environmental protection. According to a study by Intel, 80% of companies have never conducted an energy audit, and

only 29% invest in energy-efficient computers. The costs of managing IT services are rising, especially when energy consumption is considered. Ten years ago, about 17% of every euro invested in a new server went to power and cooling (Smith, 2014).

2. GREEN COMPUTING

According to Gartner, a leading global information technology research and advisory firm, "Green IT (or Green Computing) is the practice of designing, manufacturing, using, and disposing of computer, server, and associated systems (including monitors, printers, storage devices, and networking and communications systems) efficiently and effectively with minimal or no environmental impact." (Gartner, 2024)

ISO (International Organization for Standardization) does not provide a single, universally accepted "definition" of green computing or green IT in the form of a specific separate standard, but the concept of green IT is deeply embedded in their broader standards for environmental and energy management. The main objectives, which are in line with ISO principles, include:

- Reducing energy consumption: Focusing on energy efficiency of hardware and software, optimizing data center operations (e.g. efficient cooling systems, use of renewable energy sources). This is particularly emphasized in ISO 50001.
- Minimizing electronic waste (e-waste): Promoting the long life of equipment, the recyclability, reuse and proper disposal of electronic products.
- Reducing the use of hazardous substances: Designing and manufacturing IT equipment with minimal use of harmful chemicals.
- Conserving natural resources: Encouraging the use of recycled materials and sustainable resources in manufacturing.
- Reducing greenhouse gas emissions: Overall reducing the carbon footprint of IT operations, which can be measured and tracked according to standards such as ISO 14064.

The most relevant ISO standards related to green computing are:

- ISO 14001:2015 - Environmental management systems — Requirements with guidance for use (International Organization for Standardization, 2015)
    - This is the most important international standard for environmental management systems (EMS). Although it does not specifically mention "green IT", it provides a generic framework that any organization can apply to manage its environmental responsibilities, including those related to IT infrastructure. Organizations implementing ISO 14001 must identify, monitor and improve their environmental aspects and impacts, which directly includes IT energy consumption, e-waste management, etc.
- ISO 50001:2018 - Energy management systems — Requirements with guidance for use (International Organization for Standardization, 2018)
    - This standard provides a framework for establishing, implementing, maintaining and improving an energy management system (EnMS). It is particularly relevant for green IT because energy efficiency is a key aspect of

green computing, especially in data centers. Organizations that apply ISO 50001 systematically reduce energy consumption and improve their energy efficiency, which directly contributes to "greener" IT.

- ISO 14064 (series) - Greenhouse gases (International Organization for Standardization, 2018)
    - This series of standards provides guidance for quantifying and reporting greenhouse gas emissions and removals. It is relevant to green IT because the IT sector is a significant contributor to emissions, and these standards help organizations accurately measure and manage their IT-related "carbon footprint".
    - ISO 14064-1:2018 - Specifications with organization-level guidance for the quantification and reporting of greenhouse gas emissions and removals.
- ISO 14040:2006 - Environmental management - Life cycle assessment - Principles and framework (International Organization for Standardization, 2006)
    - This standard provides the principles and framework for life cycle assessment (LCA) of products and services. In the context of green IT, this means analyzing the impact of IT equipment (from raw materials, production, transportation, use to disposal) on the environment.

3. COMPUTER SECURITY

Computer security (also computer security, cybersecurity, digital security, information technology (IT) or information and communication (ICT) security) is a subdiscipline within the field of information security. It consists of the protection of computer software, systems and networks from threats that can lead to unauthorized information disclosure, theft or damage to hardware, software, or data, as well as from the disruption or misdirection of the services they provide. (“Computer Security”, 2025)

(ISC)² (International Information System Security Certification Consortium) is a leading non-profit organization that focuses on the education and certification of cybersecurity professionals. (ISC)² concept of information security is based on the so-called CIA triad: (Gennung & Benett, 2023)

- Confidentiality: Ensuring that information is available only to authorized individuals. This includes protection against unauthorized access, inspection or disclosure of data.
- Integrity: Maintaining the accuracy and completeness of information and processing methods. This means that the data was not changed without authorization or by accident.
- Availability: Ensuring that authorized users have timely and reliable access to information and systems when they need it.

The primary source for understanding (ISC)²'s approach to IT security is their Common Body of Knowledge (CBK). The CISSP CBK is a comprehensive framework that covers eight domains of information security, including: (Gennung & Benett, 2023)

1. Asset Security

2. Communication and Network Security
3. Identity and Access Management (IAM)
4. Security Operations
5. Software Development Security
6. Security Architecture and Engineering
7. Security and Risk Management
8. Security Assessment and Testing

These domains, together with the (ISC)² Code of Ethics, constitute what (ISC)² considers essential for comprehensive ICT security.

4. ICT CERTIFICATIONS

The growth and development of ICT technologies and their consequent increasing demand for workers with specialized skills have placed significant demands on the traditional education system to provide a qualified and sustainable workforce. (Valenčić, Miholjek, Skendžić, 2023) In response to advances in computer technology and the slow response of traditional education, the IT industry is using certification as a way to train and accredit its workers. (Moch, 2013) Skillsoft has released its annual report for 2022 on the most popular IT certifications in the world. According to the report, 91% of IT professionals hold at least one certification. In fact, respondents hold an average of four certifications in their field, 41% of which were acquired in the last six months. (Valenčić, Miholjek, Skendžić, 2023)

There are many benefits that employee certification brings to companies, such as: (Valenčić, Miholjek, Skendžić, 2023)

- Increased organizational productivity: The key to faster productivity growth is the ability to combine new technologies with the right human capital.
- Increased available skills: Today's organizations are increasingly facing a shortage of professional skills in some fast-growing technological areas.
- Improved efficiency and reduced risk: One of the causes of reduced efficiency is the loss of experts in the organization. Recently, an increasing number of organizations are willing to pay for various types of professional certification of their employees.
- Increased employee satisfaction: Certification builds self-confidence and increases motivation.

A 2022 survey found that hiring managers cite specific benefits of certified staff: (Valenčić, Miholjek, Skendžić,2023)

- 45% believe that certification increases productivity,
- 44% believe that the certification meets the client's requirements,
- 37% believe that certification shortens the time to solve problems,
- 35% believe that certification enables faster completion of projects,
- 35% believe that certification provides a competitive advantage.

4.1. IT SECURITY CERTIFICATIONS

Certification organizations are bodies that set standards and conduct examinations for individuals and organizations, certifying their skills and compliance with certain security practices. (Valenčić, Miholjek, Skendžić, 2023)

Organizations that develop and issue ICT security certificates (for individuals and systems) and are globally recognized for their certificates are as follows:

- (ISC)²: One of the world's largest organizations for information security. Their certifications like CISSP (Certified Information Systems Security Professional) are highly respected and sought after in the industry. They also offer other certifications such as CCSP (Certified Cloud Security Professional) and SSCP (Systems Security Certified Practitioner). ((ISC)², 2025)
- ISACA: A global organization focusing on information security management, auditing and risk management. Their most famous certificates are CISM (Certified Information Security Manager) for information security managers and CISA (Certified Information Systems Auditor) for auditors of information systems. (ISACA, 2025)
- CompTIA: Offers a wide range of IT certifications, including those in cyber security. Their most famous security certifications are CompTIA Security+ (basic cyber security certification), CySA+ (Cybersecurity Analyst) and CASP+ (Advanced Security Practitioner). (CompTIA , 2025)
- EC-Council: Known for its CEH (Certified Ethical Hacker) certification, which trains professionals to think like an attacker to better protect systems. (EC-Council, 2025)
- GIAC (Global Information Assurance Certification): Offers a range of specialized and technically deep cybersecurity certifications, such as GSEC (Security Essentials Certification) and GCIH (Certified Incident Handler). (GIAC, 2025)
- Microsoft and Cisco: As major manufacturers of software and network equipment, they offer their own certifications related to the security of their products and platforms (eg Microsoft Certified: Azure Security Engineer Associate, Cisco Certified Network Associate - CCNA Security). (Cisco, 2025, Microsoft, 2025)
- Cloud Security Alliance (CSA): Focuses on cloud security and offers certifications like CCSP (in collaboration with (ISC)²). (GIAC Certifications, 2025)
- ISO (International Organization for Standardization): Although ISO does not certify directly, they develop international standards such as ISO 27001 (information security management system). Certification according to ISO 27001 is carried out by accredited certification bodies. (International Organization for Standardization, 2022)

4.2. GREEN COMPUTING CERTIFICATIONS

Several organizations offer certificates for individuals in the field of Green computing, which validate knowledge and skills in the application of sustainable practices in information technology. Here are some of the more notable ones:

- ITCERTS (Green IT Foundation Certification Exam): This is an entry level certification for IT professionals who want to confirm their knowledge of green computing. It covers

topics such as basic concepts, definitions, drivers of green business and environment, regulations (REACH, RoHS, EPEAT, Cap and Trade), energy efficiency, virtualization, green data centers, e-waste and recycling. (ITcerts, 2025)

- IFGICT (International Federation of Green ICT): IFGICT offers certifications such as "Green IT Professional" that equip IT professionals with the knowledge and skills to implement sustainable IT practices within organizations. The certificate covers a wide range of topics, including the role of IT professionals in green ICT, the impact of green ICT on business, green ICT strategy, green data center design and green cloud computing. (IFGICT, 2025)
- BCS (British Computer Society): BCS offers "Green IT" e-learning modules to help individuals and organizations reduce their carbon emissions through smarter use of technology. These modules are useful for developing a deeper understanding of green computing and practical application. (BCS, 2025)
- Green DiSC (Digital Sustainability Certification): Although Green DiSC is more focused on research groups and central teams, it can also be relevant for individuals working in research with computing. Its goal is to reduce the environmental impact of computer research. (University of Warwick, 2025)
- Online courses and certificates from platforms like Class Central. Also many reputable universities and educational platforms (for example The Open University, TU Munich) offer free online courses and certificates in the field of green computing, covering topics from the impact of IT on the environment to green software engineering and energy-efficient data centers.

It is important to note that "green certificates" often also refer to certificates for companies and products (for example TCO Certified, Energy Star, EU Ecolabel), which certify that products or processes are environmentally friendly. However, the above organizations specifically offer certifications *for individuals* who wish to develop and validate their knowledge and skills in the field of sustainable computing. (Class Central, 2025. Open University, 2025).

4.3. IT CERTIFICATIONS IN DEMAND

Every year lists of the most demanded ICT certifications are published by various technology IT websites. Examples of such lists are the following:

1. Top 17 IT Certifications in Demand
   https://www.indeed.com/career-advice/career-development/top-it-certifications
2. Top 10 IT Certifications in Demand for 2025: Which One Is Right for You?
   https://www.101labs.net/top-10-it-certifications-in-demand-for-2025-which-one-is-right-for-you/
3. The 23 Best IT Certifications in Demand for 2025
   https://jumpcloud.com/blog/best-it-certifications
4. Top IT Certifications in Demand Today in 2025
   https://lomatechnology.com/blog/top-it-certifications-in-demand/6176

5. Top 15 IT Certifications in 2025
   https://www.uninets.com/blog/top-it-certifications

Table 1: IT Certifications in demand

Web site	# Certs	IT Security Certifications	Green computing certifications
1.	17	• Certified Data Privacy Solutions Engineer (CDPSE) • Certified Cloud Security Professional (CCSP) • Certified Ethical Hacker (CEH) • Certified Information Security Manager (CISM) • Certified Information Systems Auditor (CISA) • Certified Information Systems Security Professional (CISSP) • Certified in Risk and Information Systems Control (CRISC) • GIAC Security Essentials	• None
2.	10	• CompTIA Security+ • Certified Information Systems Security Professional (CISSP) • Certified Ethical Hacker (CEH)	• None
3.	23	• Certified Data Privacy Solutions Engineer (CDPSE) • Certified Cloud Security Professional (CCSP) • Certified Ethical Hacker (CEH) • Certified Information Security Manager (CISM) • Certified Information Systems Security Professional (CISSP) • CompTIA Security+	• None
4.	10	• Certified Information Systems Security Professional (CISSP) • Certified Ethical Hacker (CEH) • CompTIA Security+	• None
5.	15	• CompTIA Security+ • Certified Information Systems Security Professional (CISSP) • Certified Ethical Hacker (CEH) • Certified Information Systems Auditor (CISA) • CompTIA Cybersecurity Analyst (CySA+)	• None

In Table 1, it can be seen that out of the 5 selected lists for the year 2025, out of a total of 75 IT certificates, as many as 25 of them refer to IT security, that is, as much as 33,3%, while not a single certificate related to Green IT was listed (similar results are also found in the other 15 web sites that were reviewed, but not analyzed in this paper). Other IT certificates (66.6%) are certificates in networking, software development, cloud computing, AI, project management and other IT areas.

5. IT SECURITY AND GREEN COMPUTING CERTIFICATES

In general, Green computing as a separate domain is rarely directly stated as a primary focus in standard ICT security certifications. However, the implications and practices of green computing can be covered indirectly, especially in domains dealing with:

- Resource management (Asset Management): This can include the safe disposal of IT equipment (e-waste), which is a key aspect of green computing. Inadequate disposal can lead to leakage of sensitive data.
- Security Architecture and Engineering: Designing energy-efficient systems and data centers can be mentioned as part of infrastructure optimization, although the primary focus is on security.
- Incident Management and Disaster Recovery: Energy efficiency and resilience of infrastructure can contribute to faster recovery and reduction of operational costs, including energy.
- Risk Management: Risks associated with inefficient use of resources or non-ecological practices can be part of a broader risk analysis, although the focus is on security threats.

Information on the integration of green computing into certification programs for ICT security mostly shows that it is not the primary domain, but certain aspects can be touched indirectly. The connection of selected IT security certificates with Green Computing is as follows:

- CISSP (Certified Information Systems Security Professional) by (ISC)²: Learning about safe disposal of hardware and media (e-waste) is part of the "Asset Security" domain, but there is no in-depth focus on energy efficiency or the ecological footprint of IT, as explained in CISSP Certification Exam Outline. ((ISC)², 2025)
- CISM (Certified Information Security Manager) by ISACA: CISM focuses on the management and monitoring of information security. Although not directly concerned with green computing, energy efficiency and sustainability can be considered in the context of business process optimization and risk management, with an emphasis on security implications, as explained in CISM Exam Content Outline. (ISAAC, 2025).
- CompTIA Security+: As a core certification, CompTIA Security+ covers safe disposal of hardware and media in the context of data protection but does not delve into broader aspects of green computing such as energy efficiency or carbon footprint reduction, as explained in Security+ Certification Content Outline. (CompTIA, 2025)

5. CONCLUSION

The term Green computing refers to the use of IT technologies in an environmentally responsible manner. The idea of green computing is to encourage the use of more energy-efficient computing devices and reduce resource and energy consumption, thereby ensuring both the reduction and proper disposal of electronic waste. Green computing is also one of the solutions to the problem of hazardous electronic waste, which has become a global challenge, not just a local problem.

The Zero Waste model is an approach to resource and waste management that reduces the amount of waste sent to landfills or incineration and increases the amount of waste that is reused and recycled. The goal of the Zero Waste model is to eliminate waste by creating a closed system in which resources are constantly circulating and only changing form. In this way, this model promotes a sustainable way of life and production and reduces the negative impact on the environment ("Computer Security", 2025). There are five key principles of the circular economy. These are sustainable design, repair and maintenance, reuse, recycling and finally returning materials to nature (Velte, 2008, "Circular economy", 2025, "William McDonough", 2025)

If we're going to avoid a climate disaster, we need to find better ways to do pretty much everything. Almost every part of modern life—from the food we eat to the buildings we live in—releases greenhouse gases that trap heat in the atmosphere. We need to zero out those emissions in order to avoid the worst effects of climate change. (Gates, 2021)

Gartner emphasizes that Green computing includes the goal of "maximizing economic value and promoting social responsibility." (Gartner, 2024)

Due to all of the above, the application of green computing (which includes the zero waste model and the circular economy) in today's IT systems is extremely important.

The CompTIA Green IT certification (introduced in 2010) was designed to validate knowledge and skills necessary to implement environmentally sound techniques within an organization's IT infrastructure. Anyway, the certification CompTIA Green IT was retired on December 31, 2013. CompTIA explained that the reason for this was that "at this point in 2013, green IT has become embedded in the way companies generally do business" making a separate certification less necessary. (CompTIA, 2013)

Industrial certificates are the basic driver for the development and spread of a certain IT technology. Today (and for many years, because the last more widespread CompTIA Green IT certificate was canceled back in 2013) the influence of certificates related to green computing is negligible in the IT industry, while cybersecurity certificates are extremely widespread and influential (and as shown in Table 1, they make up about 33% of all significant IT certificates). Due to the importance of Green computing, and the connection with the Cybersecurity area, the author of this article recommends that Green computing technologies be shown in more detail and included as integral parts of Cybersecurity certificates (for example, as one additional domain in ISC2 CISSP certificates).

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